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DIODE STEP STRESS TESTING PROGRAM

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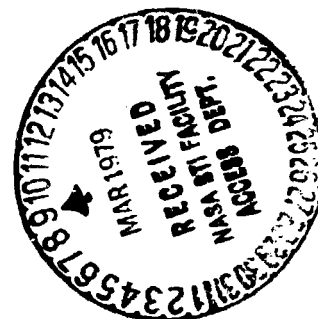
FINAL REPORT
FOR
JANTX 1N1202A

JANUARY 1979

Prepared
For

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.



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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the switching diode JANTX-1N1202A manufactured by General Electric and International Rectifier.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-speed Computer-controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to a maximum rated power (MRP). All remaining devices were



subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power for a total of 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I.

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed. Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot



failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 General Electric

The General Electric sample lot completed the entire 2500-hour Group I Testing with four catastrophic failures. The first two failures occurred 50 hours into the 100 percent MRP step. Serial Numbers 9312 and 9319 failed because of excessive I_R leakage. The next failure occurred 500 hours into the 125 percent MRP step. Serial Number 9307 failed because of excessive I_R leakage. The final failure occurred 500 hours into the 150 percent MRP step. Serial Number 9315 failed due to excessive I_R leakage. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 7.799 μA from an initial mean of 2.841 μA to a final mean of 10.64 μA .
 - 2) The mean value for V_F changed 79.0mV from an initial mean of 1.176V to a final mean of 1.097V.
- The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 International Rectifier

The INR sample lot completed 2010 hours before the lot was stopped because of a failure rate of 50 percent of the lot. The first five failures occurred 50 hours into the 100 percent MRP step.



Serial Numbers 9365, 9366, 9368 and 9372 failed because of excessive I_R leakage. Serial Number 9367 failed the maximum V_F limit. The next two failures occurred 250 hours into the 150 percent MRP step. Serial Numbers 9362 and 9363 failed due to excessive I_R leakage. The last failure occurred 500 hours into the 150 percent MRP step. Serial Number 9364 failed the maximum V_F limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 482.5nA from an initial mean of 332.7nA to a final mean of 815.2nA.
- 2) The mean value for V_F changed 16.0mV from an initial mean of 1.114V to a final mean of 1.130V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress Process for the two electrical parameters and all measurement points for both General Electric and International Rectifier.

3.2 Group II - Temperature Stress I

3.2.1 General Electric

The GE sample lot completed 960 hours before the lot was stopped because of a failure rate exceeding 50% of the lot. The first failure occurred 160 hours into the 150°C-temperature steps. Serial Number 9347 failed due to excessive I_R leakage. The next failure occurred 160 hours into the 175°C-temperature step. Serial Number 9351 also failed because of excessive I_R



leakage. The last ten failures occurred 160 hours into the 200°C-temperature step. Serial Numbers 9339, 9340, 9341, 9342, 9345, 9346, 9348, 9349, 9350 and 9353 all were removed from the testing as visual rejects because the anode leads detached due to stress. Typical characteristics of this lot's performance were:

- 1) The mean value for I_R changed 5.70nA from an initial mean of 247.9nA to a final mean of 253.6nA.
- 2) The mean value for V_F changed 54.0 mV from an initial mean of 1.202V to a final mean of 1.256V.

The control units for this sample lot remained constant throughout the Group II Testing.

3.2.2 International Rectifier

The INR sample lot completed 160 hours before the lot was stopped because of nine visual failures. Serial Numbers 9391, 9401 and 9405 were rejected because the anode leads detached due to stress. Serial Numbers 9395, 9393, 9400, 9402, 9403 and 9408 were removed because the anode leads broke off due to handling. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 53.64nA from an initial mean of 40.36nA to a final mean of 94.00nA.
- 2) The mean value for V_F changed 35.0mV from an initial mean of 1.269V to a final mean of 1.304V.

The control units for this sample lot remained constant throughout the Group II Testing.

3.2.3 Statistical Summary - Group II

Table 5 of this report outlines the results of Group II - Temperature Stress I testing for the two electrical parameters and all of the



measurement points pertaining to General Electric and International Rectifier.

3.3 Group III - Temperature Stress II

3.3.1 General Electric.

The GE sample lot completed the entire 112-hour Group III Testing with a total of two catastrophic failures. Both failures occurred 16 hours into the 275°C-temperature step. Serial Numbers 9324 and 9328 failed because of excessive I_R leakage. Typical characteristics of this lot's performance were:

- 1) The mean value for I_R changed 32.74μA from an initial mean of 175.6nA to a final mean of 32.92μA.
 - 2) The mean value for V_F changed 70.0mV from an initial mean of 1.168V to a final mean of 1.238V.
- The control units for this sample lot remained constant throughout the Group III Testing.

3.3.2 International Rectifier. The INR lot completed the entire 112-hour Group III testing with four catastrophic failures. Two devices were pulled 16 hours into the 200°C-temperature step. Serial Numbers 9379 and 9390 were removed from the testing as MIL-S-19500 limit failures at this point. The first two catastrophic failures occurred 16 hours into the +250°C temperature step. Serial Numbers 9383 and 9386 failed because of excessive I_R leakage. Two devices were pulled 16 hours into the 200°C temperature step. Serial Numbers 9379 and 9390 were removed from the testing as MIL-S-19500 limit failures at this point. Serial Number 9382 was removed from the



testing as a MIL-S-19500 limit failure. The last two catastrophic failures occurred 16 hours into the +275°C temperature step. Serial Numbers 9387 and 9388 failed because of excessive I_R leakage. Serial Number 9382 was removed from the testing as a MIL-S-19500 limit failure. Serial Number 9384 was removed from the testing as a MIL-S-19500 limit failure. Typical characteristics of this lot's performance were:

- 1) The mean value of I_R changed 38.13 μ A from an initial mean of 203.5nA to a final mean of 38.33 μ A.
 - 2) The mean value of V_F changed 56.0mV from an initial mean of 1.109V to a final mean of 1.165V.
- The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II testing for the two parameters and all of the measurement points pertaining to both General Electric and International Rectifier.

4.0 TNAJ DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures



encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0

CONCLUSIONS

The Group II - Temperature Stress I Testing proved to be the most damaging to both General Electric and International Rectifier (INR). The INR sample lot also showed signs of weakness in the Power Stress - Group I Testing. In this testing, the INR diodes seem to have failed due to thermal effects from the excess Power Stress Test. The failure modes included metal melting which disconnected and shorted internal die connections, and alloying of metal with the silicon. In the Group II Testing, many visual failures were seen from both manufacturers. These visual failures suggest that both the International Rectifier and General Electric devices failed because they were unable to withstand the high temperature developed by the Thermal Stress Test. There was universal failure of the seal between the tubulation and glass.

The General Electric devices also exhibit a major weak point where the internal wire lead is attached to the active cell.

A plot showing cumulative failure distribution for Groups II and III was drawn for the General



Electric sample lot (Figures 2 and 3), but a plot for the International Rectifier sample lot could not be drawn due to an absence of failure points in the Group II Testing (Figures 4 and 5). Figures 2 and 3 display the data for the General Electric sample lot used to calculate an activation energy of 1.18eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was drawn using the least square method.

The activation energy was calculated from the formula:

$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^\circ\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^\circ\text{C}$ of 16% failure for Group II.

T_2 = temperature in $^\circ\text{C}$ of 16% failure for Group III.



JANTX1N1202A

NOTE:

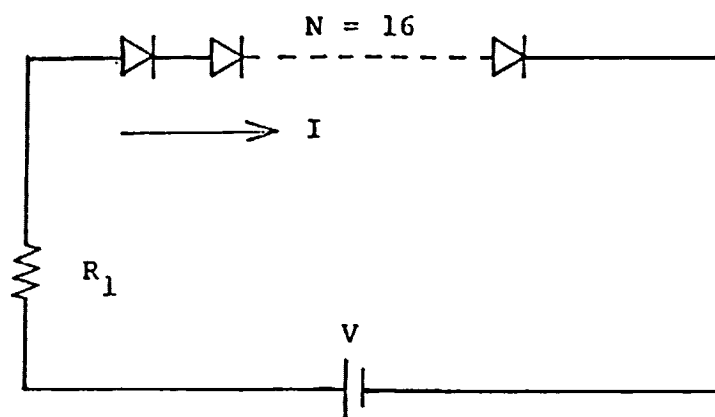
*** Conditions for failure:**

- A) Open or short
- B) Leakage exceeds the maximum limit by 100 times
- C) Other parameters exceed MIL limits by 50% or more.



JANTX1N1202A

SWITCHING DIODES



$$R_1 = 1V/I \pm 1\%$$

$$P_d = IE$$

FIGURE 1

Power and Temperature Stress Circuit
for JANTX1N1202A

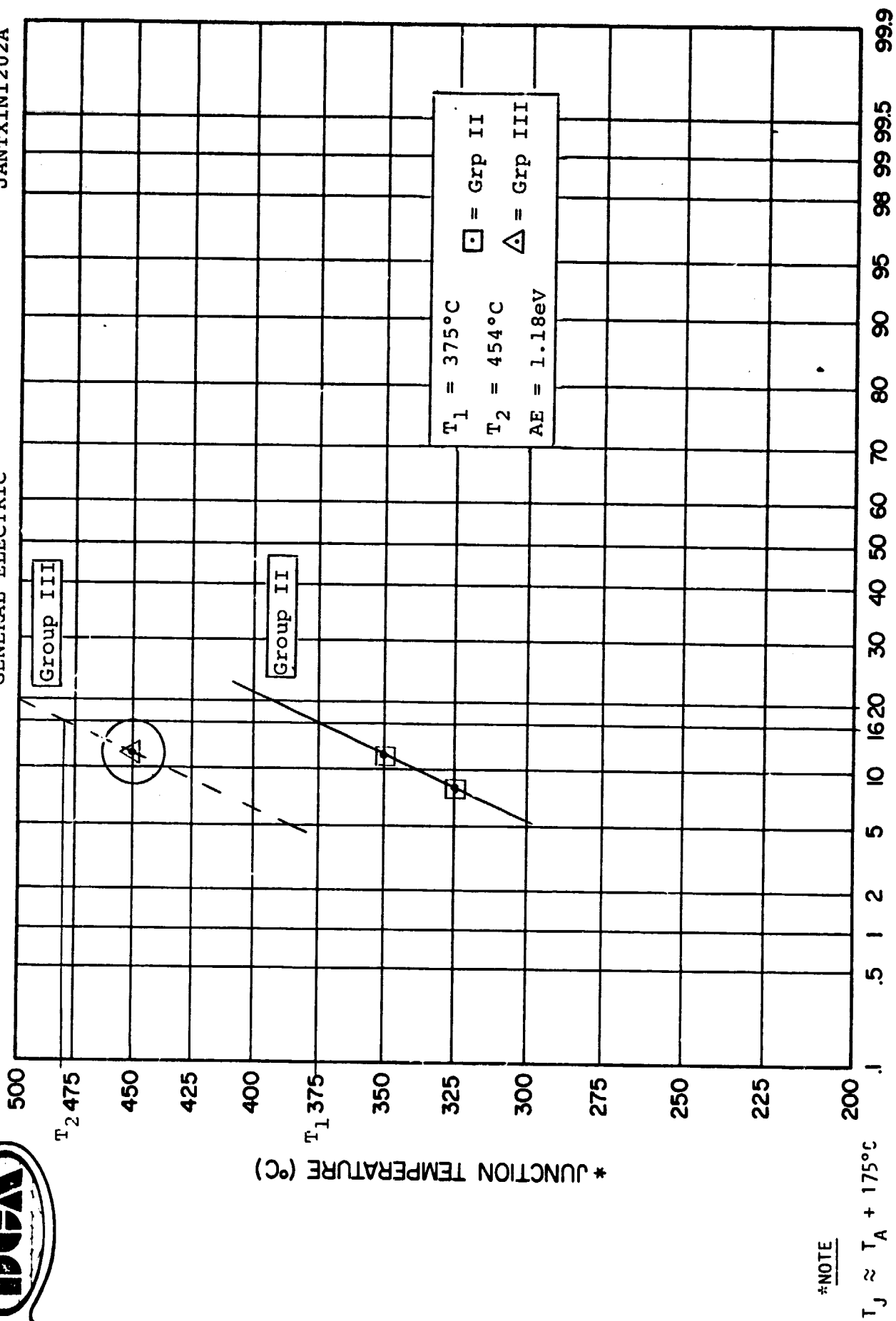
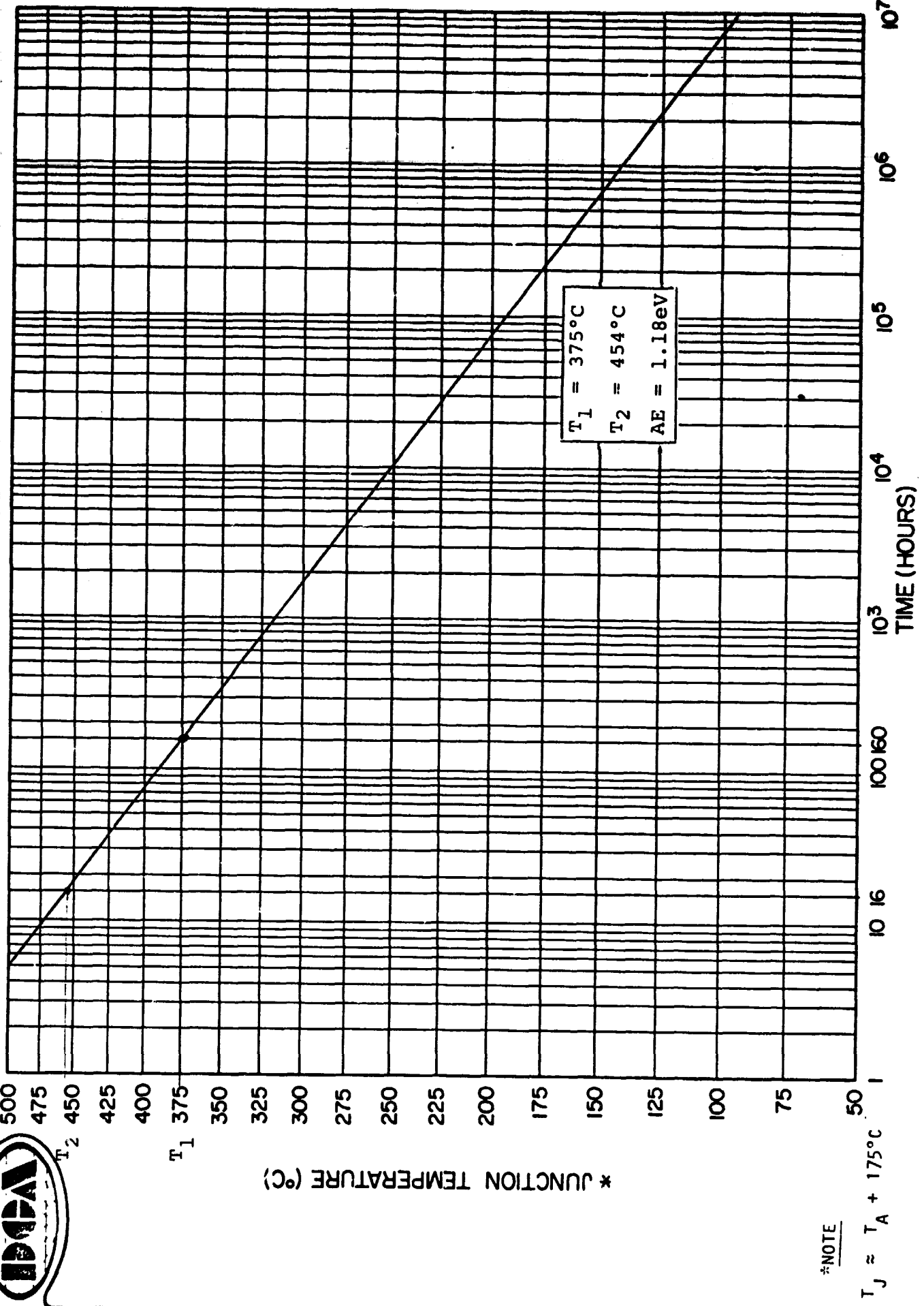


FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, General Electric



*NOTE

$T_J \approx T_A + 175^{\circ}\text{C}$

FIGURE 3
Time Steps Versus Junction Temperature, General Electric

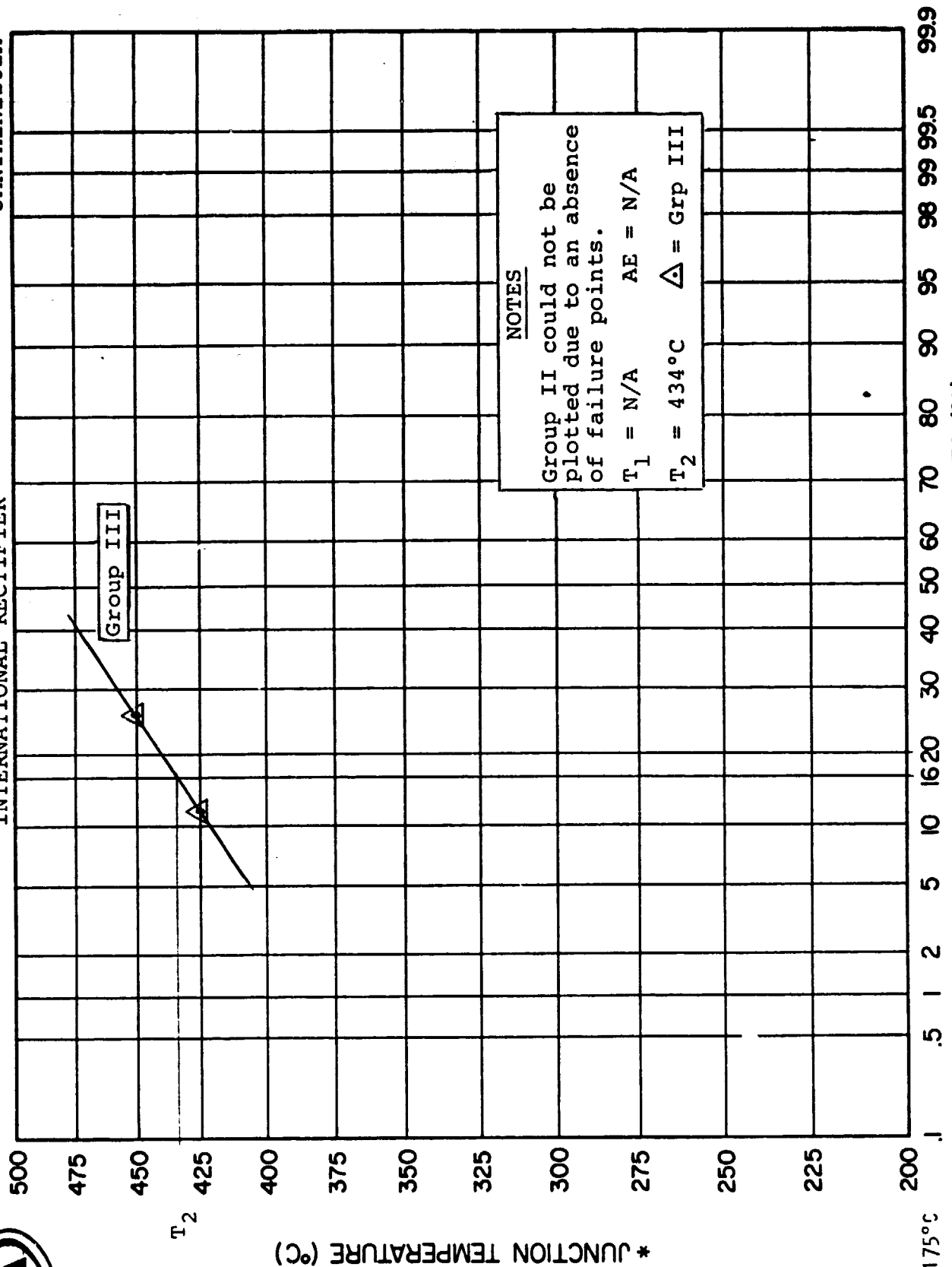


FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, International Rectifier

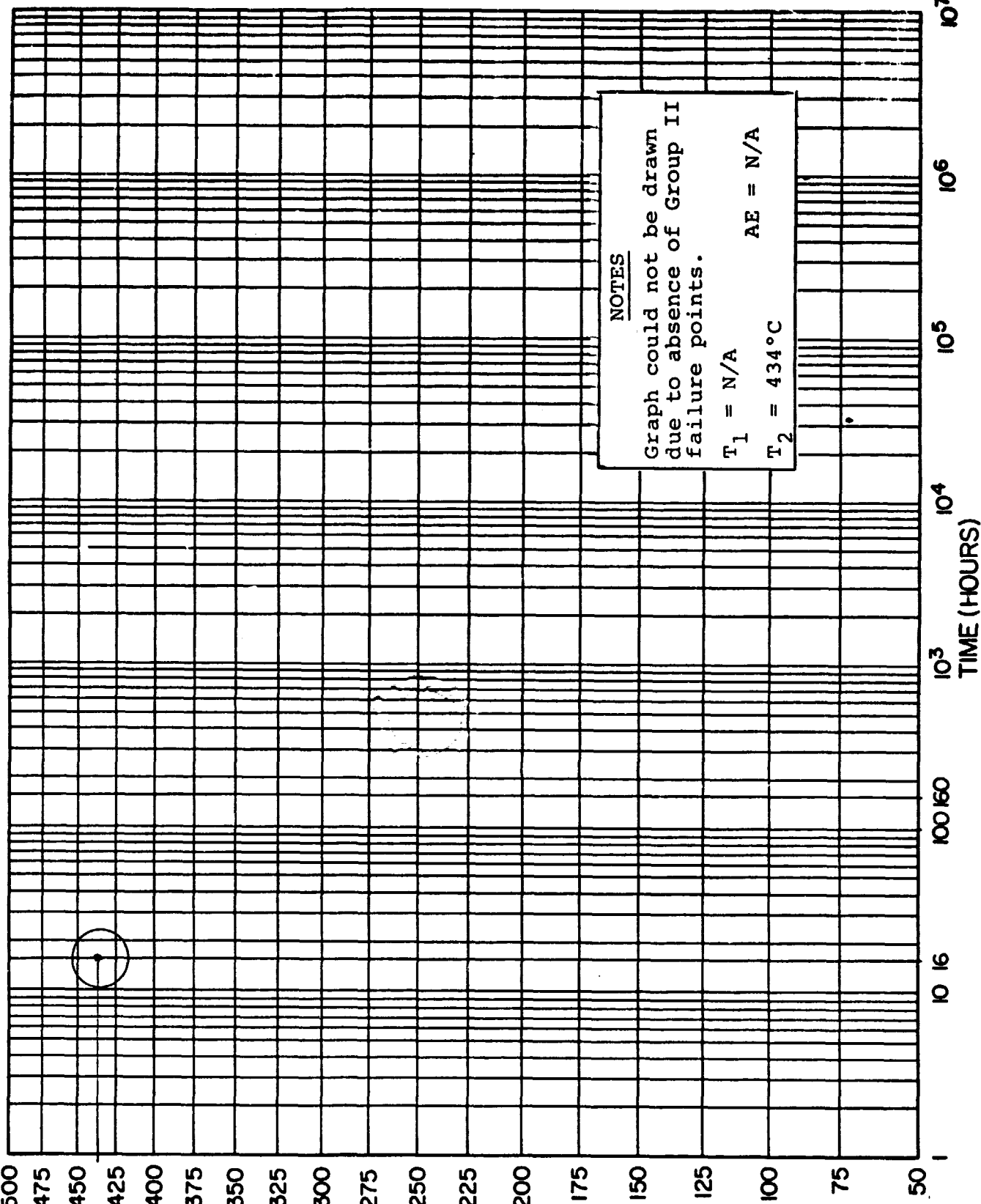


* JUNCTION TEMPERATURE (°C)

 T_2

*NOTE

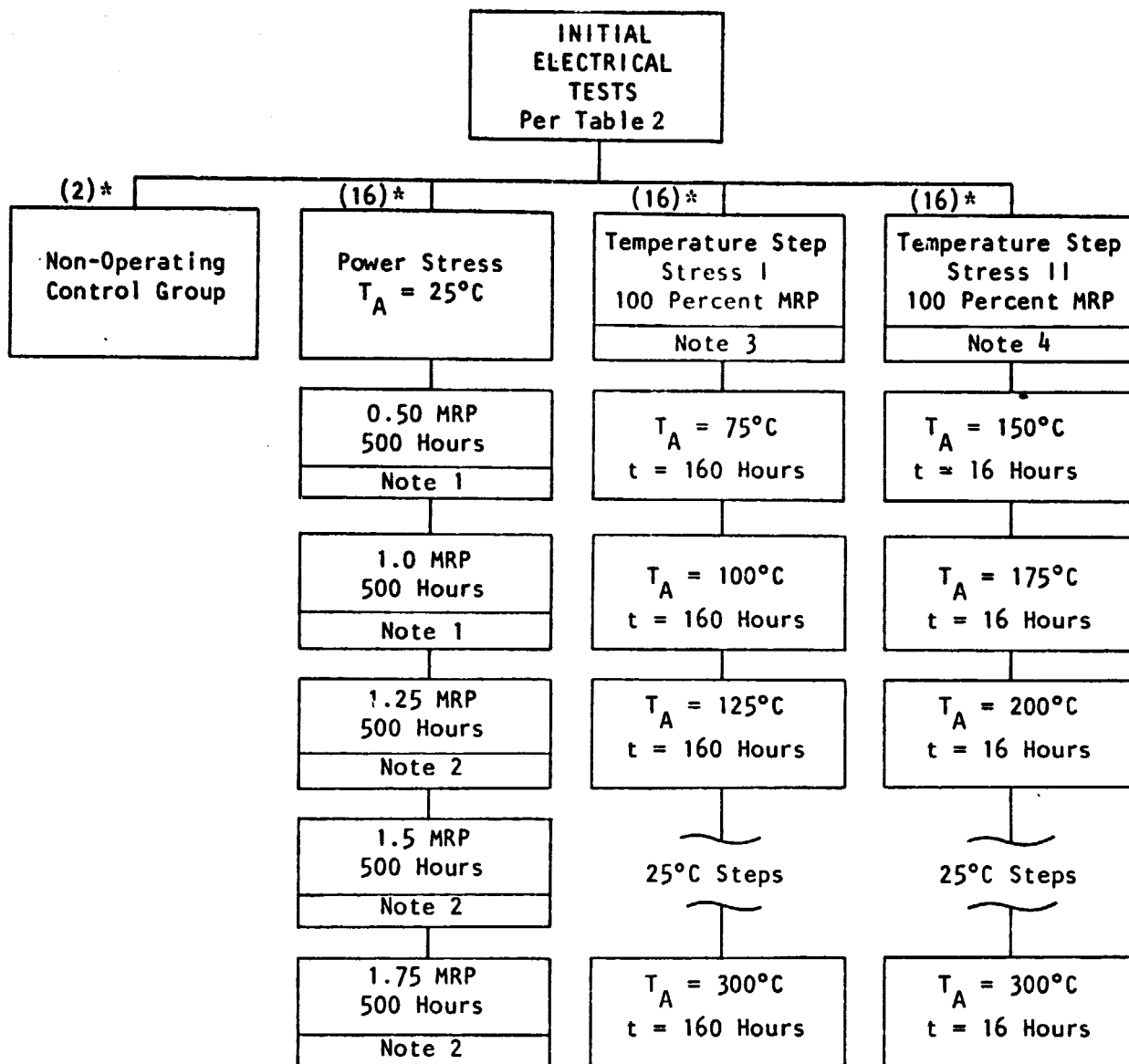
$$T_J \approx T_A + 175^\circ\text{C}$$



TIME (HOURS)

FIGURE 5

Time Steps Versus Junction Temperature, International Rectifier

TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (GENERAL ELECTRIC & INTERNATIONAL RECTIFIER)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.



JANTX1N1202A

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ $V_R = 200V$		50		5000	μA
V_F	@ $I_F = 38A(PK)$ PULSED		1.35		2.025	V(PK)

NOTES:

1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_F = 1.0V$	
$I_F =$	Percent P_D
3.0A	50
6.0A	100
7.5A	125
9.0A	150
10.5A	175



NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and \pm one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and \pm one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I - POWER STRESS DATA SUMMARY

Page 1 of 2

PARAMETER	$I_R = 50\mu A(\text{MAX})$	$V_F = 1.35V(\text{MAX})(\text{PK})$		
CONDITIONS AND LIMIT	$V_R = 200V$	$I_F = 38A(\text{PK})(\text{PULSED})$		
IDENTIFICATION	GE	INR	GE	INR
INITIAL DATA				
MIN VALUE	52.10nA	2.130nA	1.144V	1.064V
MAX VALUE	42.60 μA	4.330 μA	1.215V	1.195V
MEAN	2.841 μA	332.7nA	1.176V	1.114V
STD DEV	10.27 μA	1.049 μA	21.95mV	32.41mV
INTERIM DATA				
POWER 50 TO 125%				
Δ MEAN VALUE				
50% POWER				
50 HRS	-754 μA	-247.2nA	-0.00V	3.0mV
150 HRS	-825 μA	-168.0nA	2.00mV	12.0mV
250 HRS	-375 μA	-171.3nA	63.40mV	9.0mV
500 HRS	-495 μA	-218.0nA	9.00mV	11.0mV
100% POWER				
550 HRS	*2.221 μA	*1.465 μA	3.00mV	6.0mV
650 HRS	2.944 μA	1.212 μA	3.00mV	24.0mV
750 HRS	6.923 μA	-44.80nA	8.00mV	29.0mV
1000 HRS	-2.667 μA	168.6nA	-0.00V	37.0mV
125% POWER				
1010 HRS	-2.431 μA	335.0nA	3.00mV	30.0mV
1025 HRS	-2.374 μA	-70.30nA	15.00mV	39.0mV
1050 HRS	-1.469 μA	-103.7nA	11.00mV	39.0mV
1150 HRS	-303 μA	2.317 μA	9.00mV	36.0mV
1250 HRS	2.241 μA	-91.90nA	9.00mV	38.0mV
1500 HRS	*713.6 μA	-329.6nA	8.00mV	36.0mV

(continued on second sheet)

TABLE 4 (Cont'd)
GROUP I - POWER STRESS DATA SUMMARY

Page 2 of 2

(continued from first sheet)

PARAMETER	$I_R = 50\mu A$ (MAX)		$V_F = 1.35V$ (MAX) (PK)		
CONDITIONS AND LIMITS	$V_R = 200V$		$I_F = 38A$ (PK) (PULSED)		
IDENTIFICATION	GE	INR	GE	INR	
INITIAL DATA					
MIN VALUE	52.10nA	2.130nA	1.144V	1.064V	
MAX VALUE	42.60μA	4.330μA	1.215V	1.195V	
MEAN	2.841μA	332.7nA	1.176V	1.114V	
STD DEV	10.27μA	1.049μA	21.95mV	32.41mV	
INTERIM DATA					
POWER 150 TO 175% Δ MEAN VALUE					
150% POWER					
1510 HRS	-0.618μA	210.8nA	7.00mV	35.0mV	
1525 HRS	1.663μA	6.251μA	7.00mV	31.0mV	
1550 HRS	3.804μA	3.053μA	8.00mV	31.0mV	
1650 HRS	1.270μA	2.089μA	5.00mV	31.0mV	
1750 HRS	15.37μA	-27.50nA	18.00mV	35.0mV	
2000 HRS	*20.98μA	*5.848μA	11.00mV	26.0mV	
175% POWER					
2010 HRS	6.731μA	482.5nA	12.0mV	16.0mV	
2025 HRS	19.69μA	JOB STOPPED	12.0mV	JOB STOPPED	
2050 HRS	46.48μA	JOB STOPPED	12.0mV	JOB STOPPED	
2150 HRS	4.841μA	JOB STOPPED	24.0mV	JOB STOPPED	
2250 HRS	7.829μA	JOB STOPPED	46.0mV	JOB STOPPED	
2500 HRS	7.799μA	JOB STOPPED	-79.0mV	JOB STOPPED	
FINAL DATA					
MIN VALUE	99.90nA	7.410nA	510.0mV	1.110V	
MAX VALUE	67.00nA	5.110μA	1.220V	1.160V	
MEAN	10.64μA	815.2nA	1.097V	1.130V	
STD DEV	21.99μA	1.541μA	190.1mV	20.62mV	

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

GROUP	II	TEMP	STRESS	I	DATA SUMMARY
-------	----	------	--------	---	--------------

PARAMETERS		$I_R = 50\mu A$ (MAX)		$V_F = 1.35V$ (MAX) (PK)	
CONDITIONS AND LIMITS		$V_R = 200 V$		$I_F = 38$ (PK) (PULSED)	
IDENTIFICATION		GE	INR	GE	INR
INITIAL DATA					
MIN VALUE		37.40nA	2.31GnA	1.160V	1.110V
MAX VALUE		1.550μA	409.0nA	1.310V	1.460V
MEAN		247.9nA	40.36nA	1.202V	1.269V
STD DEV		386.4nA	98.70nA	35.04mV	88.49mV
INTERIM DATA (INITIAL TO FINAL)					
Δ MEAN VALUE					
TOTAL HRS	TEMP (T _A)				
160	75°C	10.05μA	*53.64nA	1.0mV	35.0mV
320	100°C	-247.7nA	JOB STOPPED	2.0mV	JOB STOPPED
480	125°C	-221.8nA	JOB STOPPED	2.0mV	JOB STOPPED
640	150°C	*631.2μA	JOB STOPPED	18.0mV	JOB STOPPED
800	175°C	*666.0μA	JOB STOPPED	52.0mV	JOB STOPPED
960	200°C	5.700nA	JOB STOPPED	54.0mV	JOB STOPPED
1120	225°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
1280	250°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
1440	275°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
1600	300°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED
FINAL DATA		200°C	75°C	200°C	75°C
FINAL TEMP (T _A)					
MIN VALUE		33.40nA	2.240nA	1.220V	1.130V
MAX VALUE		1.010μA	1.310μA	1.380V	1.530V
MEAN		253.6nA	94.00nA	1.256V	1.304V
STD DEV		378.7nA	314.4nA	62.48mV	113.9mV

NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY (16 HR)

JANTX1N1202A

PARAMETERS	$I_R = 50\mu A$ (MAX)		$V_F = 1.35V$ (MAX) (PM)			
CONDITIONS AND LIMITS	$V_R = 200V$		$I_F = 38A$ (PK) (PULSED)			
IDENTIFICATION	GE	INR	GE	INR		
INITIAL DATA						
MIN VALUE	20.60nA	1.630nA	1.120V	1.020V		
MAX VALUE	463.0nA	1.630 μA	1.220V	1.190V		
MEAN	175.6nA	203.5nA	1.168V	1.109V		
STD DEV	127.2nA	449.6nA	25.62mV	40.45mV		
INTERIM DATA						
(INITIAL TO FINAL)						
Δ MEAN VALUE						
TOTAL HRS	TEMP (T_A)					
16	150°C					
32	175°C					
48	200°C					
64	225°C					
80	250°C					
96	275°C					
112	300°C					
	59.91 μA	40.1nA	2.0mV	2.0mV		
	40.93 μA	-73.9nA	5.0mV	5.0mV		
	1.162 μA	-114.4nA	38.0mV	38.0mV		
	15.86 μA	-120.6nA	28.0mV	45.0mV		
	14.38 μA	*1.332mA	38.0mV	78.0mV		
	*1.139mA	*1.816mA	49.0mV	154.0mV		
	32.74 μA	38.13 μA	70.0mV	56.0mV		
FINAL DATA						
FINAL TEMP (T_A)	300°C		300°C		300°C	
MIN VALUE	68.30nA	4.860nA	1.180V	1.120V		
MAX VALUE	337.0 μA	297.0 μA	1.460V	1.250V		
MEAN	32.92 μA	38.32 μA	1.238V	1.165V		
STD DEV	89.12 μA	97.81 μA	71.63mV	37.75mV		

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.



TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			GE	INR	GE	INR	GE	INR
I_R		50.0	μA		*+32.772	*+1.0457	*+217.80	+0.05364	*+186.28	*+455.12
V_F		1.35	V		+0.00871	+0.02638	+0.02150	+0.03500	+0.03286	+0.05400

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.



FAILURE SUMMARY

STEP STRESS CATASTROPHIC

TABLE 8

GROUP I POWER STRESS

GROUP II 160 HR. TEMP. STEPS

GROUP III 16 HR. TEMP. STEPS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	2	A	4	A B
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	1	A	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	2	A
250 hr.	1	A	1	B
175% 10 hr.	0	-	0	JOE STOPPED
15 hr.	0	-	0	JOE STOPPED
25 hr.	0	-	0	JOE STOPPED
100 hr.	0	-	0	JOE STOPPED
100 hr.	0	-	0	JOE STOPPED
250 hr.	0	-	0	JOE STOPPED

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	3	C
100°C	0	-	0	JOE STOPPED
125°C	0	-	0	JOE STOPPED
150°C	1	A	0	JOE STOPPED
175°C	1	A	0	JOE STOPPED
200°C	10	C	0	JOE STOPPED
225°C	0	JOE STOPPED	0	JOE STOPPED
250°C	0	JOE STOPPED	0	JOE STOPPED
275°C	0	JOE STOPPED	0	JOE STOPPED
300°C	0	JOE STOPPED	0	JOE STOPPED

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	0	-	0	-
225°C	0	-	0	-
250°C	0	-	2	A
275°C	2	A	2	A
300°C	0	-	0	-

MFR "A" - GENERAL ELECTRIC

MFR "B" - INTERNATIONAL RECTIFIER

NOTES: A - $I_R > 5\text{mA}$ B - $V_F > 2.025\text{V}$

C - VISUAL (OTHER THAN HANDLING)



TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JANTXIN1202A

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	1	A	0	-
250 hr.	1	A	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	0	STOPPED
25 hr.	0	-	0	STOPPED
100 hr.	0	-	0	STOPPED
100 hr.	1	A	0	STOPPED
250 hr.	0	-	0	STOPPED

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	1	A	2	B F
100°C	0	-	0	JOB STOPPED
125°C	0	-	0	JOB STOPPED
150°C	1	A	0	JOB STOPPED
175°C	1	-	0	JOB STOPPED
200°C	0	-	0	JOB STOPPED
225°C	0	STOPPED	0	JOB STOPPED
250°C	0	STOPPED	0	JOB STOPPED
275°C	0	STOPPED	0	JOB STOPPED
300°C	0	STOPPED	0	JOB STOPPED

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	4	A	0	-
175°C	0	-	0	-
200°C	0	-	2	C
225°C	2	A	1	B
250°C	-	-	1	D
275°C	2	A	1	E B
300°C	-	-	1	A

MFR "A" - GENERAL ELECTRIC

MFR "B" - INTERNATIONAL RECTIFIER

NOTES: A - I_R LIMIT FAILUREB - V_F LIMIT FAILURE

C - S/N 9379, 9390 REMOVED FROM TESTING AS MIL-S-19500 FAILURE

D - S/N 9382 REMOVED FROM TESTING AS MIL-S-19500 FAILURE

E - S/N 9384 REMOVED FROM TESTING AS MIL-S-19500 FAILURE

F - S/N 9395, 9398, 9400, 9402, 9408, 9403 VISUAL DUE
TO HANDLING



JANTX1N1202A

APPENDIX
FAILURE ANALYSIS



JANTX1N1202A

FAILURE ANALYSIS
POWER STRESS

Date 27 October 1978

J/N 2CN242-27A P/N 1N1202A MFR INTERNATIONAL RECTIFIER

FAILURE VERIFICATION:

S/N	PIV -volts-	I_R @ 200 V.dc	V_F @ 38 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:.	INITIAL REJ. FOR:
9362	450 Uns arcs	∞	No reading	41 (150% pwr) (200 Hr. Tot)	I_R
9365	R=150	∞	5.4	11 (100% pwr) (550 Hr. Tot)	I_R
9366	R=800	∞	5.5	11 (100% pwr) (550 Hr. Tot)	I_R

INTERNAL VISUAL INSPECTION:

S/N 9362: The semiconductor die and its metal mounting disc are detached from the stud; the silicon junction coating material is completely charred and burned off the die. (See Figure A-1.)

S/N 9365: The large metal balls are wedged between the semiconductor die and the side of the case. (See Figure A-2.)

S/N 9366: This sample has no significant visual defects.

CONCLUSION:

These rectifiers failed due to the thermal effects of the excess power stress test. The failure modes included melting bonding material which disconnected and shorted internal die connections; contamination and chemical changes to the junction coating; and alloying of the bonding material with the silicon.

*^hFE trace present. Cannot meet stated test conditions. (Leaky)
**^hFE trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



JANTX1N1202A

FAILURE ANALYSIS
APPENDIX B
TEMPERATURE STRESS



JANTX1N1202A

FAILURE ANALYSIS
TEMPERATURE STRESS

Date 30 October 1978

J/N 2CN242-27B P/N 1N1202A MFR INTERNATIONAL RECTIFIER

FAILURE VERIFICATION:

S/N	PIV -volts-	I_R @ 200 V.dc	V_F @ 38 A dc	INITIAL REJ. AT TEST SEQUENCE NO.: .	INITIAL REJ. FOR:
9391	---	---	---	3 (+75°C) (160 Hrs. Tot)	Missing lead and tube
9401	>1100	<0.1μA	5.4	3 (+75°C) (160 Hrs. Tot)	Missing G/M seal & eyelet
9405	open	open	open	3 (+75°C) (160 Hrs. Tot)	Loose eyelet; cracked glass

INTERNAL VISUAL INSPECTION:

The glass-to-metal seal has come apart on all three International Rectifier samples. S/N 9391 and 9401 the tubulation was missing in the parts as received for analysis; on S/N 9405 the tube is still in place, but it can be moved within the glass seal. (See Figures B-1 and B-2.) S/N 9391 has the broken-off stub of the internal wire lead still in place on the die; S/N 9401 has the internal wire lead broken off at the height of the former crimp, and S/N 9405 has separated between the silicon die and its top metal disc contact, which is loose in the package. Most of the internal wire is missing.

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
* h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



JANTX1N1202A

FAILURE ANALYSIS
TEMPERATURE STRESSDate 30 October 1978J/N 2CN242-27B P/N 1N1202A MFR GENERAL ELECTRIC**FAILURE VERIFICATION:** Limit: Limit:
50 mA Max. 2.03 V Max.

S/N	PIV -volts-	I_R @ 200 V.dc	V_F @ 38 A dc	INITIAL REJ. AT TEST SEQUENCE NO.: .	INITIAL REJ. FOR:
9342	open	open	open	13 (200°C) (960 Hrs. Tot)	Loose tube
9346	open	open	open	13 (200°C) (960 Hrs. Tot)	Loose tube
9348	700 → 300 arcs	0.1μA	no reading	13 (200°C) (960 Hrs. Tot)	Loose tube

INTERNAL VISUAL INSPECTION:

The glass-to-metal seals of all three General Electric samples have loosened, and the metal tubulations can be moved where they pass through the glass. (See Figure B-3.) The internal wires have separated where they were attached to the top metal contact plate of the silicon cell. (See Figure B-4.)

*^hFE trace present. Cannot meet stated test conditions. (Leaky)
*^hFE trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



CONCLUSION:

ALL THE IRC and GE samples failed because they were unable to withstand the high temperature developed by the thermal stress test. There was universal failure of the seal between the tubulation and glass. The GE samples also exhibit a major weak point where the internal wire lead is attached to the active cell. (See Figure B-4).

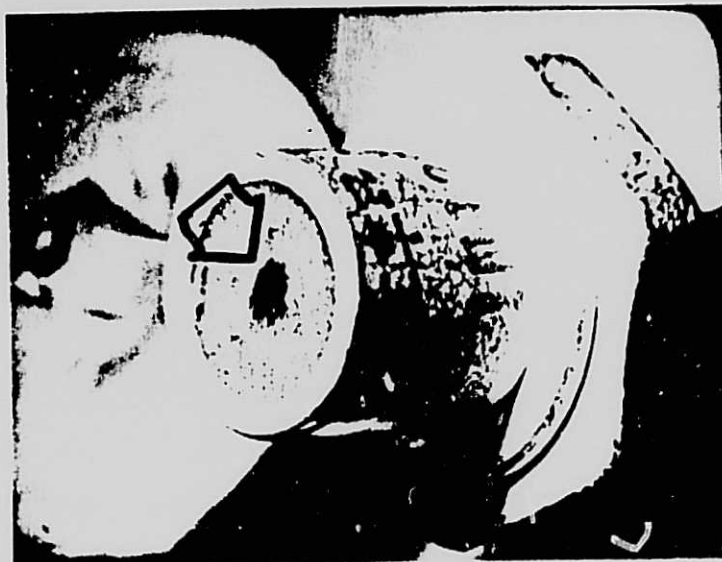


FIGURE B-1

S/N 9391, IRC SAMPLE, 5X.
Arrow indicates site of former
glass-to-metal seal.

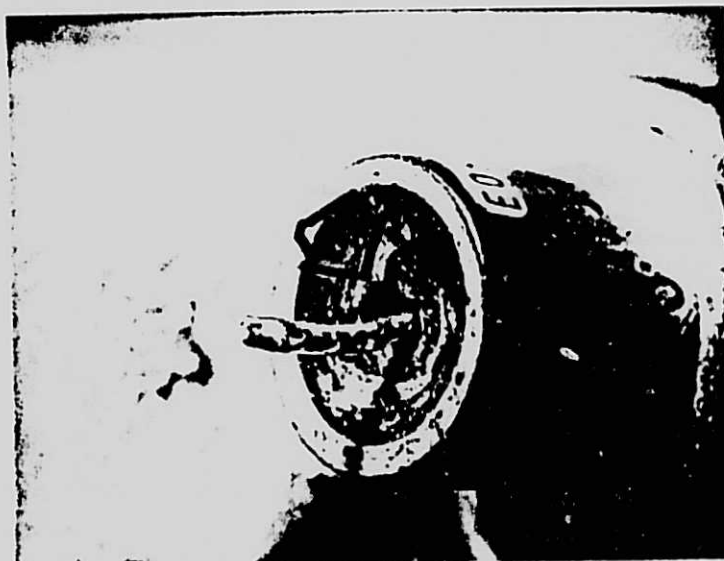


FIGURE B-2

S/N 9401, IRC SAMPLE, 5X.
Arrow indicates destroyed
glass-to-metal seal.



FIGURE A-1

S/N 9362, IRC SAMPLE, 3.3X.
Internal view of IRC device showing the
silicon die detached from the stud.

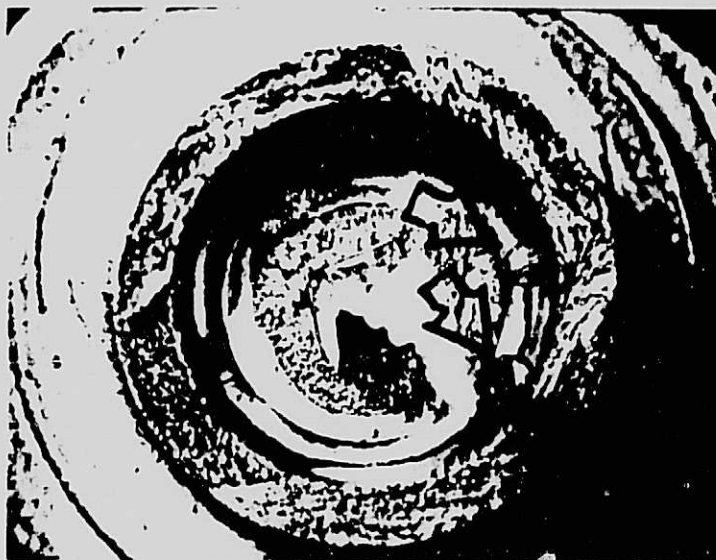


FIGURE A-2

S/N 9365, IRC SAMPLE, 9X.
Arrows indicate metal balls at the edge
of the semiconductor die.



FIGURE B-3

S/N 9348, GENERAL ELECTRIC SAMPLE, 2.7X.
Arrow indicates loosened glass-to-metal
seal, with movable tubulation.

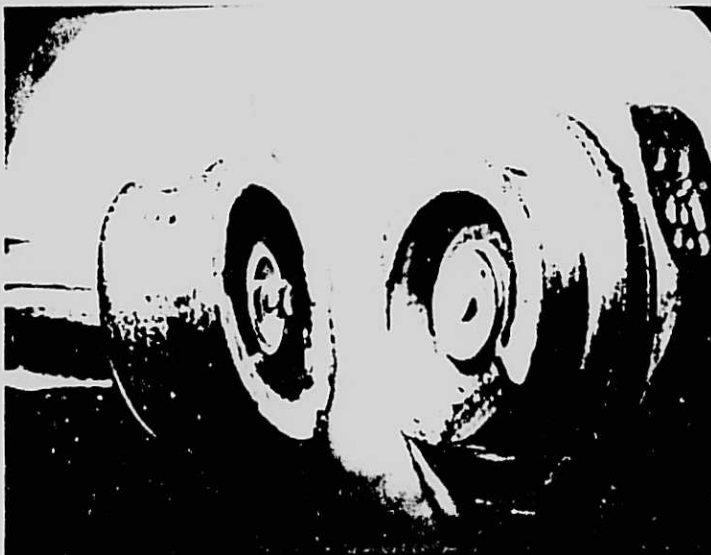


FIGURE B-4

S/N 9348, GENERAL ELECTRIC SAMPLE, 5X.
Internal view showing separation
of internal wire attachment.